

Co-60 Total Ionizing Dose (TID) Test of LT1024 Operation Amplifier

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I. Introduction

This study was undertaken to determine the total ionizing dose susceptibility of the LT1024 at Goddard Space Flight Center (GSFC) Co-60 Radiation Effect Facility. LT1024 is a Dual Channel, Matched Picoampere, Microvolt Input, Low Noise Operation Amplifier from Linear Technology Corporation

II. Devices Tested

Five parts were exposed to Cobalt-60 source. All devices were characterized prior to exposure. Three devices were from date code of Q8D0114A and two devices were from date code of Q8D0137A. In addition, one control device from date code Q8D0137A was set aside and the measurement of the control devices was taken as well. Complete device details are given in Table I.

III. Test Facility

Facility: GSFC Co-60 Radiation Effects Facility

Source: Cobalt 60

Dose Rate: 0.72 krad(Si)/hour

IV. Test Method

Five LT1024 (S/N 012, 016, 018, 110 and 111) were exposed to the Co-60 radiation environment at 12 rad/min (0.72 krad/hour) rate. The devices were biased with $\pm 12V$ and two input terminals were grounded. The bias circuit is shown in Figure 1.

Prior to the first exposure, initial measurements were taken for all samples (five radiation samples one control sample). Then five samples were exposed to Co-60 in increment steps. After each exposure step, those devices were taken out of the Co-60 cell, and post-irradiation measurements were performed. There were all together six exposure characterizations done at approximately 2, 4, 8, 12, 16 and 30 Krads(Si). Table II shows the radiation exposure schedule.

If there was a long interval after the previous exposure, an additional measurement was taken before the next exposure. There were three such measurements. They are:

- prior to 8 krad exposure (16 hours interval between 4 krad and 8 krad),
- prior to 12 krad exposure (18 hours interval between 8 krad and 12 krad),
- prior to 16 krad exposure (66 hours interval between 16 krad and 30 krad).

Devices were kept unbiased at the room temperature during the intervals. All other intervals between exposures were minimal (less than 30 minutes).

Keithley 2010 Digital Multimeter was used to take parametric measurement along with the Kenwood 4 Channel Power Supply. Supply current, Input Offset Voltage and Input Bias Current were measured using an application specific test circuit. The data specifications of these parameters from Linear Technology Corporation are shown in Table III.

V. Result

The results from the testing are detailed in Table IV. Table IV contains the averaged results for the two cases where S/N 12 device is included or not. The reason for this is that this device showed abnormal device characteristics, even before exposure to the radiation.

The following conclusions can be made from the data excluding S/N 12: (1) Parametric failure occurred between 2 and 4 krads with V_{os} going out of specification. (2) Functional failure is greater than 30 krads. While the V_{os} and input bias current are well out of specification by 30 krads, the devices continued to operate in the test circuit.

Table I. Part Information

Generic Part Number:	LT1024AMD
STEREO Part Number:	
Charge Number:	
Manufacture:	Linear Technology Corporation
Lot Date Code (LDC):	Q8D0114A (S/N 012, 016, & 018) Q8D0137A (S/N 108, 110, & 111)
Quantity Tested:	6
Serial Number of Control Samples:	108
Serial Numbers of Radiation Samples:	012, 016, 018, 110 and 111
Part Function:	Dual-Channel Operation Amplifier
Part Technology:	
Package Type:	14-Pin CDIP
Test Equipment:	Kenwood Power Supply Keithley 2010 Multimeter
Test Engineer:	Hak S. Kim

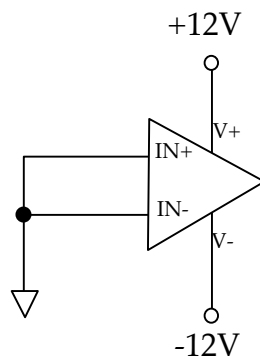


Figure 1. Radiation Bias Circuit per Channel

Table II. Radiation Schedule

Event	Date
1) Initial Electrical Measurement	10/15/03
2) 2.0 Krad Irradiation (0.72 Krad/Hour)	10/15/03
Post-2.0 Krad Electrical Measurement	10/15/03
3) 4.0 Krad Irradiation (0.72 Krad/Hour)	10/15/03
Post-4.0 Krad Electrical Measurement	10/15/03
4) Pre-8.0 Krad Electrical Measurement	10/16/03
8.0 Krad Irradiation (0.72 Krad/Hour)	10/16/03
Post-8.0 Krad Electrical Measurement	10/16/03
5) Pre-12.0 Krad Electrical Measurement	10/17/03
12.0 Krad Irradiation (0.72 Krad/Hour)	10/17/03
Post-12.0 Krad Electrical Measurement	10/17/03
6) Pre-16.0 Krad Electrical Measurement	10/20/03
16.0 Krad Irradiation (0.72 Krad/Hour)	10/20/03
Post-16.0 Krad Electrical Measurement	10/20/03
7) 30.0 Krad Irradiation (0.72 Krad/Hour)	10/20/03
Post-30.0 Krad Electrical Measurement	10/21/03
8) 148 Hour Annealing @25°C	10/21/03
Post-148 Hour Anneal Electrical Measurement	10/27/03

Table III. Electrical Characteristics of LT1024 (of Parameters Measured)

Symbol	Parameter	Condition	Specification Min Typ Max	Unit
+Icc	+Supply Current per Amplifier	V+ = +15V V- = -15V V _{CM} = 0V T _A = 25°C	380 600	mA
-Icc	-Supply Current per Amplifier			mA
Vos	Input Offset Voltage		15 50	mV
Ibias	Input Bias Current		<u>±</u> 20 <u>±</u> 120	pA

Table IV. Summary of Electrical Measurements of LT1024

Exposure	Control Sample								Radiation Samples								1) Radiation Samples excluding S/N 012							
	Icc+ (mA)		Icc- (mA)		Vos (mV)		Ibias (pA)		Icc+ (mA)		Icc- (mA)		Vos (mV)		Ibias (pA)		Icc+ (mA)		Icc- (mA)		Vos (mV)		Ibias (pA)	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Initial	0.43	1.28E-02	0.43	2.40E-03	-7.5	1.80E+01	-91.5	3.54E+00	0.42	4.84E-03	0.42	3.67E-03	-70.9	1.99E+02	-91.7	4.24E+01	0.42	4.89E-03	0.42	3.28E-03	-8.6	1.67E+01	-94.0	2.78E+01
2 Krad	0.43	1.29E-02	0.43	2.47E-03	-7.7	1.83E+01	-94.0	7.07E+00	0.42	4.68E-03	0.42	3.50E-03	-94.7	1.99E+02	-532.0	1.69E+02	0.42	4.60E-03	0.42	2.97E-03	-33.4	1.85E+01	-496.3	9.88E+01
4 Krad	0.43	1.28E-02	0.43	2.33E-03	-6.9	1.99E+01	-93.5	6.36E+00	0.41	4.76E-03	0.42	3.61E-03	-124.9	1.99E+02	-1111.5	3.63E+02	0.41	4.71E-03	0.41	3.11E-03	-64.9	2.05E+01	-1039.9	2.07E+02
2)pre-8 Krad	0.43	1.28E-02	0.43	2.40E-03	-10.6	5.94E+00	-52.5	1.39E+02	0.41	4.72E-03	0.42	3.59E-03	-121.6	1.98E+02	-1083.3	3.58E+02	0.41	4.72E-03	0.41	3.13E-03	-61.7	2.03E+01	-1028.6	2.58E+02
8 Krad	0.43	1.28E-02	0.43	2.40E-03	-7.6	1.90E+01	-88.5	3.54E+00	0.41	4.95E-03	0.41	3.75E-03	-194.5	2.04E+02	-2492.3	8.54E+02	0.41	5.10E-03	0.41	3.62E-03	-135.1	3.06E+01	-2333.3	4.36E+02
3)pre-12 Krad	0.43	1.29E-02	0.43	2.40E-03	-7.4	1.87E+01	-56.5	4.31E+01	0.41	4.87E-03	0.41	3.80E-03	-188.8	2.03E+02	-2294.8	7.64E+02	0.41	5.04E-03	0.41	3.65E-03	-129.9	3.04E+01	-2150.0	4.15E+02
12 K rad	0.43	1.29E-02	0.43	2.40E-03	-8.2	1.92E+01	-85.0	4.24E+00	0.41	5.20E-03	0.41	4.10E-03	-291.7	2.17E+02	-4490.6	1.66E+03	0.41	5.53E-03	0.41	4.28E-03	-233.0	4.90E+01	-4192.4	8.39E+02
4)pre-16 Krad	0.43	1.28E-02	0.43	2.40E-03	-6.9	1.92E+01	-94.5	2.12E+00	0.41	5.02E-03	0.42	4.11E-03	-287.5	2.16E+02	-3972.9	1.48E+03	0.41	5.36E-03	0.41	4.22E-03	-229.2	4.92E+01	-3684.4	7.18E+02
16 Krad	0.43	1.29E-02	0.43	2.40E-03	-7.5	1.86E+01	-87.5	7.78E+00	0.41	5.58E-03	0.42	4.58E-03	-421.1	2.38E+02	-7098.4	2.67E+03	0.41	6.05E-03	0.42	5.02E-03	-363.4	8.04E+01	-6661.0	1.47E+03
30 Krad	0.43	1.29E-02	0.43	2.40E-03	-7.5	1.90E+01	-85.0	5.66E+00	0.41	7.83E-03	0.42	7.30E-03	-1088.9	3.98E+02	-25494.9	9.51E+03	0.41	8.40E-03	0.42	8.25E-03	-1033.7	2.40E+02	-24337.9	5.89E+03
148 hr Anneal	0.43	1.28E-02	0.43	2.40E-03	-8.3	1.95E+01	-88.5	7.07E-01	0.41	5.08E-03	0.42	4.09E-03	-770.2	2.72E+02	-21619.3	6.90E+03	0.41	5.37E-03	0.41	4.36E-03	-717.2	1.28E+02	-20823.3	4.28E+03

Notes:

1) Serial Number 012 showed high deviation from the rest of the samples even for the initial measurement.

2),3),4) Because of time intervals between irradiation steps, pre-exposure measurements were taken.

The intervals were:

2) – 16 hours

3) – 18 hours

4) – 66 hours

Devices were kept unbiased at the room temperature during the intervals